Digital Transformation Through Internet of Things Services

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Abstract

Internet of Things (IoT) have been disrupting industries through shifting novel services, and business models. Organizations should also redesign their business service models to navigate this disruption. A holistic understanding of digital transformation through IoT requires the cooperation of multiple disciplines ranging from engineering to economics. This paper utilizes a conceptual model to develop an analytical framework to investigate a number of pricing strategies enabled by different business models. Our findings demonstrate that the Internet of Things phenomenon has the potential to disrupt the way we do business by connecting markets and enabling new business models.

1. Introduction

In the world of ever-changing business models, organizations require utilize technologies to profoundly enhance their performances and to gain sustainable competitive advantage. Internet of Things (IoT) is one of the drivers of this digital transformation in this competitive age. Businesses are expected to meet new targets, seek new opportunities and avoid new threats as they face competition against connected services enabled through IoT. Digital technologies have changed the business models on many levels. First, these technologies created synergies among markets that were previously detached. They allowed collaboration through advanced and richer ways of communication. Technologies have also opened new horizons for new data collection, storage, processing, along with many other ways to disrupt conventional way of conducting business.

Digital transformation is the implementation of digital technology applications that accelerate the business activities and competencies to leverage the opportunities. Searching, finding, and processing information became easier and cheaper because of digital transformation. It enhances effective and faster communication. Organizations that utilize IoT services can collect business data from sensors, and also automatically take actions without human intervention before service is impacted. [1] Organizations can use this collected information to achieve competitive advantages by improving business process and offering better services. [2]

Digital transformation includes digitalizing the business operation, adopting technologies and thus changing the business environment. Embracing technologies and digitalization enable organizations advancing towards digital transformation. In the growing business internet-based technologies, IT operations limit the required expertise in order to sustain a competitive advantage. The need arises for synchronizing new operational technologies with existing administration focused information technology system. Converging Operation Technology and Information Technology ameliorate business performances, maximizes business efficiency and process management tools to have accurate information at a given time in its best form. The rapid and massive growth of mobile devices and traffic gives a good example of combining these two technologies in digital transformation. This growth allows people and thing to communicate faster at any given time and also, enable enterprises and government agencies to monitor and control digital devices remotely in real time. The integration of these two technologies create opportunities for businesses and provide greater economic benefit. Though there are some key challenges underlie this integration. Another challenge for manufacturers are for remote locations, limited resources, multiple technologies, mobility require remodeling the procedures.

In this paper, we explore the driving forces and key challenges in embracing the IoT phenomenon. We develop a prospectus for new business models and use analytical modeling framework to initiate this transformation.

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1.1 Technological components of IoT

Specialized computing tools of IoT make the principal layer of complexity. The first layer is the "**Things**". These are the autos, refrigerators, and other smart devices. To put it plainly, they are the ordinary tools that we use with no computing or information processing capacities. With the coming of IoT, we are transforming these non-smart tools into processing mediums.

The second component is the **Internet** and corresponding hardware, software and service providers. Hardware providers produce the switches, routers, modems and other networking software required to provide internet services. Cisco, Juniper, etc. are examples of hardware providers. Software providers provide some of the software like switching software, speed optimization algorithms, etc., that are used to provide optimum bandwidth and speed. Finally, there are service providers such as Comcast, Frontier, Century link, etc., who provide internet access to both commercial establishments and homes.

The third component is **hardware** that is required to enable the "Things" to use the Internet for communications. This hardware can be a part of our everyday objects that functions to collect data and transmit it to the platform. Hardware can come in various forms like integrated circuits, SIM cards, sensors, etc. Companies like Honeywell, Akita electronics, Samsung are examples of hardware manufacturers.

The fourth component is the **platform** that provides the required intelligence to analyze the data and provide a decision. This is the heart of the IoT system and is responsible for collecting the data from the 'Things', store it in a database that is either local or on the cloud and is responsible for the analysis of data and corresponding decisions. Intelligent Systems from Microsoft, Internet of Everything from Cisco, etc. are examples of commercially available platforms. Of the four IoT components, the platform is the most complex and is the binding factor for all the other components. It collects the data from the 'Things', uses logic and intelligence to make a decision, and communicates it back to the 'Things' using the hardware and Internet.

Taken together, Figure 1 displays the related components of IoT. The complexity of the IoT system creates more than a few market end-users. As such, it presents numerous combinations of ownership that need attention if an organization chooses to serve these users. To better understand these possible combinations of ownership we explore what constitutes a platform and how the components interact with each other in the following section.

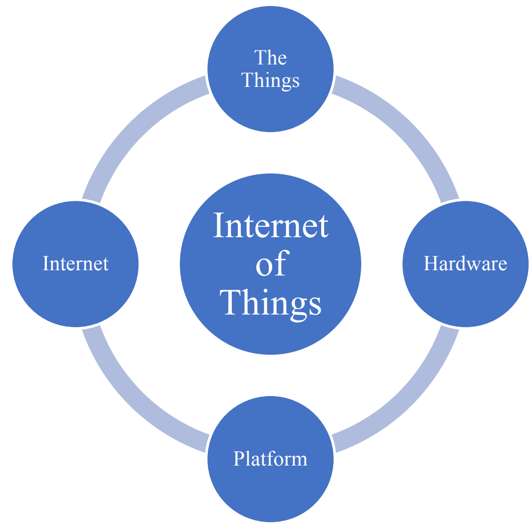

Figure 1. Technological components of IoT

1.2 Offerings/sides in the IoT market

Consumers are typically an important player in any market. However, in the IoT market, the term "consumer" is rather confusing. Consumers of IoT can be end-users of a system or consumer of a particular platform, device or service. For example, the end-user of any connected "Thing" is obviously a consumer. However, a car manufacturer (such as Ford) can also be a consumer when it buys Sync service or other intelligent solutions from Microsoft. To summarize, one side of the market can be a consumer for another. In this study, to avoid any confusion about consumer identification and market offerings, we will use the word "consumers" only for the end users.

Figure 2 represents the connected offerings of a multi-sided market. The "Things" manufacturers are those producers that offer **durable goods**. These are the manufacturers of everyday objects such as cars, refrigerators, or vending machines. Examples of manufacturers are Toyota and Frigidaire. Typically, these manufacturers expect a one-time payment for their product. In a conventional market, strategies of durable goods manufacturers are relatively simple. For example, if the firm is a monopolist it can maximize its revenue and it is bounded by Coase theorem [3] in the presence of a strategic consumer. In competition, the firm can use the Bertrand model [4] to set a price, or the Cournot model [5] to set a quantity and then solve for optimal strategies. However, if a market has more than two offerings or sides with network effects, as current research suggested, conventional economic approaches such as Coase theorem fails and market will not be efficient [6, 7].

Telecom platform providers offer telecommunication networks in various different technologies. For example, Verizon is a cellular provider and an integral part of the IoT ecosystem since the communication signals run on their platform. We categorize any communication service provider under the telecom platform category.

Security is one of the main concerns in the IoT industry before customers adopt smart things at a larger scale. This requirement is similar to any other internet-enabled technological market. Telecom providers will be the main player in the IoT industry to address security and privacy concerns of customers. Moreover, telecom platform providers position themselves uniquely between the customer and any other service or good seller to mitigate these concerns.

Even though today there is a debate whether standardization can lead to a more secure IoT market, prior trends indicate that different IoT technologies may converge in the future into one standardized protocol.

Consumable goods or services are another integral side of the IoT market. The main reason for a consumer to buy a smart durable good is the fact that it offers additional value in terms of consumable goods or service. For example, a smart fridge can order groceries without human intervention. Companies such as Amazon.com are already offering this service type with Amazon Fresh. However, there is a potential for any brick and mortar store to offer the same product or service to serve the IoT enabled grocery market.

IoT presents an opportunity for **advertisers** to analyze consumers. There is a tremendous amount of data coming from each smart thing owned by a consumer. Sometimes that data can be large enough to be termed as “Big Data” and novel algorithms, computing power and logic are required. The advertising service has to analyze the data coming from all the data sources and communicate the appropriate advertisement back to the device. For example, in the future your fridge can recommend different brands of milk in addition to ordering it. This provides an opportunity for sponsored durable goods, which was rarely available in the past for everyday consumers.

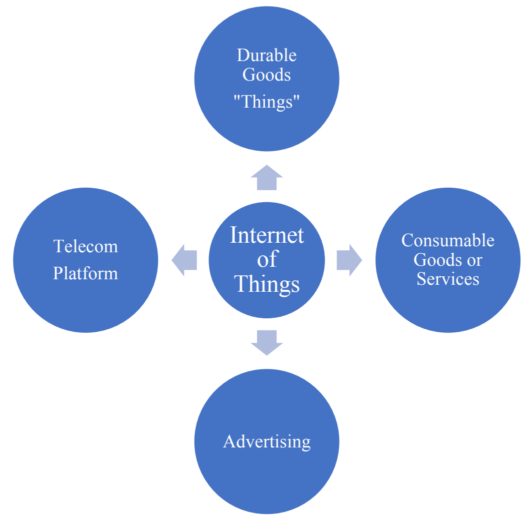

Figure 2. Offerings in the IoT market

In this study, first we define the offerings of the IoT market and explain its multi-sided nature. Subsequently, we outline four different business ownership models and their strategies. Each one of these four cases can be a guideline for IoT researchers to develop analytical models. For example, in e-commerce, researchers can develop pricing models both in monopolistic and competitive settings. In operations research, supply chain and supply web models can benefit from our conceptual framework. Our aim is to investigate the IoT market structure and identify the market offerings.

1.3 Problems not yet addressed

We are motivated with the countless problems that are not yet addressed adequately both in academia and in the industry. For example, during our preliminary open-ended interviews, we quickly discovered that people’s ability to understand the changes and their implications were limited. It is apparent that the change the rate of human capability to absorb complexities. As a result, most practitioners do not follow a scientific strategy for their critical strategies, such as pricing of IoT services.

IoT services are different from conventional technologies mainly because of their high-level of connectivity and the lack of human intervention. This requires new approaches for an organization’s risk profile. The sheer number of devices and their variability creates a complexity that’s never seen before in the past. Moreover, much of these devices connect to the systems outside a single organization.

For example, during our preliminary interviews, a high-level executive at a Fortune 500 organization (that considers itself an IoT leader) did not have a precise strategy for services pricing. This example is only one institutional component for sales and marketing. We observed this trend repeatedly for system management, analytics and even application development.

To clarify, we explore these research questions: What are the institutional components of the IoT market? Which business service models and strategies are available for a firm targeting presence in the IoT industry? In addition to the theory, we provide a strategic model for practitioners to make decisions on presence, pricing, and supply web design in each side of the IoT industry: durable goods, consumable goods and services, telecom platform, and advertising.

Literature Review

2.1 Internet of things

The term Internet of Things (IoT) first originated from a presentation given by the Massachusetts Institute of Technology researcher Kevin Ashton in 1999 at Procter & Gamble [1]. Currently, IoT term represents the "integration of the physical world with the virtual work of the Internet" [8, p. 1]. That is, the IoT is the network through which information resources may be shared between smart objects [9] and ultimately, to market entities in order to enhance the efficiency and effectiveness with which services are provided to consumers.

To demonstrate the way information resources may flow across a particular framework to provide enhanced service, we describe a grocery service example. First, there is an object of interest, a refrigerator, with machine-to-machine communication capabilities. The object of interest has certain attributes, in this case, information about the groceries inside the refrigerator that are readable by another machine. Second, there is a device that interacts with the object of interest to capture and package information. In the case of the refrigerator, a monitoring device such as a sensor may detect the current contents of the refrigerator. Third, external devices are those machines that receive information from the monitoring device through the internet and translate the information into actionable data for managed services. The managed services can exist in a number of other markets.

For example, a discovery service provider may serve as a data intermediary that connects data about the object to end-users [10]. The end-users may include service providers that react to the data, such as a local grocer that receives the information about a consumer's refrigerator contents and triggers a delivery order to refill used items. Alternatively, an advertisement firm may receive information that generates a customized set of advertisements to be mailed to the refrigerator owner.

As this example demonstrates, the flow of information across the platform effectively enhances the product-service offering. However, the network effects may be considered beyond the benefit to the consumer that owns the object of interest. That is, the IoT has essentially brought together different end-users that subsist on the information shared across the Internet. These types of network externalities have generated much interest in the way business service models may be created.

2.2 Computing technology and the IoT

Computer science and engineering research already have a considerable number of studies that define core IoT concepts and literature surveying the computing realm relevant to IoT [2].

In our search, we noticed that security issues stand out as the primary concern for the IoT technology [2, 8, 10]. As we identified four offerings in the IoT market, telecommunication platform providers appeared in a unique position, between the customer and any other firm offering IoT goods and services; therefore, they have the potential to address many of these security concerns. On the other hand, intentionally creating a less secure environment can enable fast growth similar to the case of the Internet [2].

Research direction for the IoT has a wide horizon ranging from massive scaling with knowledge creation and big data analysis informing the interactions with humans [6]. Deployment of energy efficient technologies may also continue to inspire green IoT research which investigates optimal energy usage. Although computer science and engineering research is extremely useful for technical progress, it does not address the practical need for a business service model to monetize the market. In other words, without improving knowledge about viable business service models we will continue to find new disappearing firms of the IoT industry that suffer the same fate as AltaVista and Netscape.

Firms in the IoT-enabled industry need innovative business service models to survive and flourish. Although we found one conference paper investigating business model innovation [7], it was limited to the service design processes in postal logistics. Therefore, we feel confident to claim that we are filling the gap of business service models and market presence strategies in the IoT industry.

2.3 Multi-sided markets

To understand the full complement of network externalities calls for a new perspective of the business service model. Past research has used the foundation of two-sided markets [13] to study a number of model designs and strategies with two markets (see progress report by [7]). A two-sided market can be defined as "one in which 1) two sets of agents interact through an intermediary or platform, and 2) the decisions of each set of agents effects the outcomes of the other set of agents, typically through an externality" [13]. For example, video game platforms connect players and game developers, and platforms that draw more players will attract more game developers and vice-versa. Researchers have expanded on simple two-sided markets to consider freemium models whereby one market receives a discount or free product to understand the tradeoffs of offering the discount or free information product to one side of the market versus the other [6]. Economides and Katsamakas [14] specifically looks at optimal pricing strategies of two-sided markets consisting of proprietary platforms versus open source platforms. However, researchers suggest that the two-sided market may be too simple to represent real world company strategies [15]; rather, the networked relationships that connect multiple end-users should be considered. Building on the network effects of relationships between two user groups, we consider the way users interact with each other across multiple sides of the market.

To understand business service models that incorporate the impact of information in a market with more than two sides, we consider at multi-sided market. In Table 1 we provide examples of multi-sided markets, specifically four-sided markets that extend previously conceptualized two-sided markets [16].

3. Model

In order to represent competition in IoT-enabled multi-sided markets, we expand a classic two period Hotelling model [17] to j market sides with asymmetric market shares. We use this model to investigate how prices and market shares would change over time and to explain strategies for market envelopment though externalities.

3.1 The Role of Hotelling's model

In this paper, we utilize the Hotelling's competition model for a baseline to represent an asymmetric rivalry among to firms. We would like to underline that we only use the Hotelling's model as an established method to represent the competition. We develop over this basic model through the representation of multiple sides in the IoT market.

Please note that Hotelling's model is an essential part of our formulation but it is merely used as a baseline to represent the competitive nature between IoT service providers. The focus, and the main contribution of our model is beyond Hotelling's competition, which concentrates to characterize the multiple sides in the IoT services industry. As we outlined in section 1.2, numerous offerings in the IoT industry creates multiple sides in this complex market ranging from telecom platforms to the advertising market. In this study, we aim to develop the first stylized analytical model to represent the multi-sided nature of this digital transformation.

As aforementioned in the abstract, our aim is to demonstrate that the IoT phenomenon leads to a digital transformation via disrupting the way firms do business by connecting markets. This connection creates multi-sided markets and new business models emerge to create value in these connected-ecosystems. Leaders such as Amazon and Apple has the potential the benefit from these new business models, particularly via new pricing models and strategies to grab market share.

Perhaps more significantly, these new business models has the potential to disrupt markets, along with creating new jobs or making others obsolete. Starting with the Hotelling's competition model, we aim to demonstrate that conventional pricing schemes will be inferior to the multi-sided pricing strategies. More importantly, firms that understand and employ multi-sided strategies will benefit from early capture of market share in multiple sides of the IoT-connected markets.

IoT is a relatively new field and there are many gaps in research, especially in modeling IoT services and strategies. Ehret and Wirtz [18] recommend that vast business value can be mined from IoT services through scientific analytical models. In addition, Oberländer et al. [19] suggest that virtually infinite connections among devices and people could result in a new paradigm and complexity that could only be examined through analytical tools and methods.

3.2 Operationalization of the IoT ecosystem

The notation used in this paper is in Table 1.

Table 1. Notation

Term	Definition
u	Customers' utility
i	Firm index: $i \in \{a, b\}$
t	Period: $t \in \{0,1,2\}$
c_s	Cost of switching: $c_s \sim U[0, \theta]$
e	Network effect on u
j	Market side index: $j \in \{1, 2, 3\}$
α	Marginal shifting cost
p_t^i	Price of firm i in period t
q_t^i	Quantity sold by firm i in period t
x^i	Distance from buying the service from firm i

The IoT-enabled market are served by two firms (a and b) with asymmetric initial market shares:

$$0 \leq q_0^b < 0.5 < q_0^a \leq 1$$

The asymmetric market share assumption benefits the model in two ways. First, it provides a more realistic representation of current IoT-enabled markets. Second, it covers a wider range of theoretical scenarios than an equal-market-share case.

We also assume that, in the market setting above, there is a continuum of customers uniformly distributed between firms a and b. This horizontal differentiation (which indicates that IoT-enabled service characteristics across a market side are fixed) is due to inherent characteristics of IoT services (such as customer taste, ease of operation, configurability, compatibility and security perception) rather than the physical location.

In our model setup, there are i firms in j sides of the market. Multi-sided markets develop over time, generally with the introduction of a disruptive technology because network externalities require time to affect a market. [15] For example, it took Amazon.com years to develop a viable electronic book reader platform and benefit from synergies on both sides (e-reader and e-book) of the publication market. Therefore, most multi-sided markets start with independent organizations serving each side. The best representation of a pre-competition multi-sided market is the case where firms independently serve separate sides of the market.

We consider a two-period pricing game with two firms. Price p_t^i represents the price of firm i in period t. Customers make purchase decisions based on their utilities. The term x^i is the distance of the customer buying the service from firm i. In addition, the term c_s represents any costs incurred to switch. The initial picture looks as shown in figure 3:

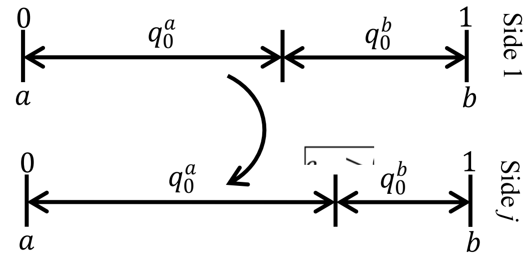

Figure 3. Illustration of the initial condition for the model

For simplicity, we denote e_{11} as e, and omit the subscript j in p_{jt}^i and q_{jt}^i. The net utility of the indifferent customer for firm a in the second period can be characterized as:

$$u - \alpha x^a - p_2^a + e q_1^a =$$
$$u - \alpha(1 - x^a) - p_2^b - c_s^a + e q_1^b$$

The indifferent customer determines new market shares for firm a and b at the end of the second period.

We use backward induction to find equilibrium prices and quantities sold to represent market shares. First, we start with the second period solution, and then we solve the maximization problem for the first period profits to find equilibrium prices and quantities sold. As mentioned in table 1, q_t^i denotes quantity sold by firm i in period t.

The net utility of firm b's indifferent customer in the second period is:

$$u - \alpha(1 - x^b) - p_2^b + e q_1^a =$$
$$u - \alpha x^b - p_2^a - c_s^b + e q_1^b$$

We can determine the new allocation of market share for firm a and b at the end of the second period by determining the quantity of switching customers. To find market shares for the second term, we start by identifying customers who switch:

Customers will switch from firm a to firm b when $c_s^a < \alpha(2x^a - 1) + p_2^a - p_2^b + e(q_1^b - q_1^a)$. Similarly, firm b customers switch to firm a when $c_s^b < \alpha(1 - 2x^b) - p_2^a + p_2^b + e(q_1^b - q_1^a)$. Please note that switching cost can be different for each customer since it is a distribution. Such switching costs bring additional trade-offs over the heterogeneity of tastes. For example, consider two customers where one is closer to firm a in tastes. Normally we would expect the closer customer to stay with firm a and the farther customer to switch, however, if the closer customer's switching cost is low, and the farther customers switching cost is high, then the farther customer can stay with the firm because of high switching costs and the closer customer may switch to the rival's service.

We assume that $\alpha < p_2^a - p_2^b$ to avoid the negative probability of switching and an interior location x for the customer. This assumption not only improves tractability in the general model, but also it is a better representation of reality. Price p in our model includes inherent penalties of switching, therefore a customer's switching cost will be less than the price difference, or else the customer would not switch. These conditions are checked for all possible cases (negative and positive) of optimal solutions.

Let n_{tj}^{kl} be the quantity of customers who bought from l in period $t-1$, and firm k in period t, in market side j. For example, customers who switched to firm b from firm a in period 2 are represented as n_{2j}^{ba}. Therefore, customers staying with firm a can be found through the following calculation:

$$n_{2j}^{aa} = \int_0^{q_1^a} \left(\int_{\alpha(2x-1)+p_2^a-p_2^b+e(q_1^b-q_1^a)}^{\theta} \frac{1}{\theta} ds \right) dx$$

$$= \frac{q_1^a(\alpha(1-q_1^a) - p_2^a + p_2^b + e(q_1^a - q_1^b) + \theta)}{\theta}$$

Customers switching from firm a to b:

$$n_{2j}^{ba} = q_1^a - n_{2j}^{aa}$$

$$= \frac{q_1^a(\alpha(q_1^a - 1) + p_2^a - p_2^b - e(q_1^a - q_1^b))}{\theta}$$

Customers staying with firm b:

$$n_{2j}^{bb} = \int_{q_1^a}^{1} \left(\int_{\alpha(1-2x)-p_2^a+p_2^b+e(q_1^b-q_1^a)}^{\theta} \frac{1}{\theta} ds \right) dx$$

$$= \frac{(q_1^a - 1)(q_1^a(\alpha + e) - q_1^b e + p_2^a - p_2^b + \theta)}{\theta}$$

Customers switching from firm b to firm a:

$$n_2^{ab} = 1 - q_1^a - n_2^{bb}$$

$$= \frac{(q_1^a - 1)(q_1^a(\alpha + e) - q_1^b e + p_2^a - p_2^b)}{\theta}$$

Market share for firm a at the end of period 2:

$$q_2^a = n_2^{aa} + n_2^{ab}$$

$$= q_1^a + \frac{p_2^b - p_2^a + e(2q_1^a - 1)(q_1^a - q_1^b)}{\theta}$$

Market share for firm b at the end of period 2:

$$q_2^b = n_2^{bb} + n_2^{ba}$$

$$= 1 - q_1^a + \frac{p_2^a - p_2^b - e(2q_1^a - 1)(q_1^a - q_1^b)}{\theta}$$

Firm i maximizes its second period profit.

$$\max_p \pi_2^i = p_2^i q_2^i$$

First order conditions give us equilibrium prices as:

$$p_2^{a*} = \frac{(1 + q_1^a)\theta + e(2q_1^a - 1)(q_1^a - q_1^b)}{3}$$

$$p_2^{b*} = \frac{(2 - q_1^a)\theta - e(2q_1^a - 1)(q_1^a - q_1^b)}{3}$$

Equilibrium quantities sold are:

$$q_2^{a*} = \frac{(1 + q_1^a)}{3} + \frac{e(2q_1^a - 1)(q_1^a - q_1^b)}{3\theta}$$

$$q_2^{b*} = \frac{(2 - q_1^a)}{3} + \frac{e(2q_1^a - 1)(q_1^a - q_1^b)}{3\theta}$$

As a result of the second period profit maximization, we obtain profits as a function of quantities sold in the first period:

$$\pi_2^{a*} = \frac{(e(2q_1^a - 1)(q_1^a - q_1^b) + (1 + q_1^a)\theta)^2}{9\theta}$$

$$\pi_2^{b*} = \frac{(e(2q_1^a - 1)(q_1^a - q_1^b) - (2 - q_1^a)\theta)^2}{9\theta}$$

For the first period maximization problem, we follow a process similar to the second period. First, we identify the indifferent customers to find switching costs c_s in terms of x^i and prices.

The net utility of the indifferent customer for firm a in the first period is:

$$u - \alpha x^a - p_1^a + e q_1^a =$$
$$u - \alpha(1 - x^a) - p_1^b - c_s + e q_1^b$$

The net utility of firm b's indifferent customer is:

$$u - \alpha(1 - x^b) - p_1^b + e q_1^a =$$
$$u - \alpha x^b - p_1^a - c_s + e q_1^b$$

Subsequently, we solve the maximization problem for the first period profits to find equilibrium prices and quantities sold. Tracing previous steps shows that there are optimal pricing strategies for firm a and b in the basic model.

Theorem: *There exists a solution for the maximum revenue in IoT-enabled markets, thus there are rational pricing strategies for firms a and b.*

Proposition 1: *Cross-market externalities increase the benefits to the market leader in terms of quantities sold.*

Proposition 2: *The market leader can charge a higher price in the presence of positive cross-market externalities without losing market share.*

Please note that these results only hold for the market share leader firm, because the externality effects across time periods conflict with the inter-market externality effects for the follower firm.

3.3 Industry examples

We are already observing the assembly of multiple market sides through various IoT service offerings and devices. A few days ago (in September 2018,) Amazon announced that it will start selling multiple IoT-enabled devices including a connected smart microwave oven that is voice controlled, learning and responding with its proprietary personal assistant Alexa. This device is more than a simple internet-connected plaything for geeks. It has the potential to connect the grocery, durable goods, and the advertising industries (if not more.) In the near future, we speculate that Amazon will offer more IoT-enabled durable goods for home and car. For example, our refrigerators and coffee makers will start to talk and collect data. Interestingly, the pricing of these devices will be well below the cost, as we predicted in our stylized model.

We are essential in the round 1 of this IoT-enabled pricing and market share strategy game. It is not too late for other firms to follow early movers such as Amazon. However, if a competitor waits too long, it can completely miss the window to benefit from IoT-enabled markets. The impact of Internet of Things are much more than technological sensors and voice recognition. IoT-enabled services has the potential to disrupt conventional industry such as groceries, that are previously thought to be relatively safe from digital transformation.

4. Conclusion

Our vision of the future IoT industry includes a firm or a set of firms that appreciate the multi-tiered nature of the market we presented in this study. At the extreme, a firm can still benefit from other complementary offerings while providing free goods and services to the customer. For example, it would not surprise us to see a smart refrigerator dominating every household because it is sold considerably under its cost with the expectation of groceries or other consumable goods and services paying for the difference along the way. Likewise, both this refrigerator and groceries can be subsidized via household consumption data collected from the smart device, similar to Google providing a free search service based on advertising. In either case, customers enjoy lowered costs while the strategic firm enjoys market domination, and scalable revenues stemming from the complementarities in this multi-sided market. On the negative side, this business service model has the potential to disrupt a number of industries including durable goods, retail, and even telecommunication.

Each case in our service design models provides a theoretical guideline for prospective research and presents an opportunity for future studies in various fields such as information goods pricing models, supply chain design, and policy development for potentially inefficient IoT markets. Beyond, IoT industry, our concepts can be used for any information systems enabled market complex enough to serve four different sides.

In addition to the theory, practitioners in the IoT industry are in dire need of strategic business ownership models because conventional models do not fully capture externalities and the multi-sided nature of this market. Using our framework, practitioners can decide if they want to offer products and services in each side of the IoT market. Before they consider this decision, they can compare aforementioned pros and cons of each case. Early ownership decisions for each side of the IoT market can mean market domination for a firm or being the next failure in a disrupted industry.

For example, a marketing manager at an IoT services organization such as Amazon could utilize our model to price their IoT-enabled services both in the basic case and in the presence of time-inconsistent discounters. In such a case, we expect to see highly-discounted durable goods in the short run in order to dominate the market. For example, Amazon could deliver IoT-enabled smart refrigerators at cost or even at a loss which could be subsidized by the groceries or by the other sides of this complex market.

On the other hand, the competition is obviously is at a disadvantage in this setting. This might force competitors to form alliances in order to gain competitive advantage and benefit from the economies of scale. For example, we wouldn’t be surprised to see IoT alliances between durable goods manufacturers (such as Samsung) and retailers (such as Walmart) in the near future.

This research has limitations due to the nature of the conceptual model research methodology. First, arguments and propositions in this study have not been tested empirically or any other method. Furthermore, conceptual models naturally adopt certain aspects in the cultural literature. Therefore, the arguments in this paper should be taken as mere propositions until they are scientifically proven.

This work can be extended as we observe how the IoT industry develops and create business service models more specific to address the needs of the customers, organizations and institutions.

Future research on IoT business service models are not limited to pricing and supply chain models. Petabytes of “Big Data” generated through advertising side of the IoT market will create an opportunity of novel empirical marketing research and even novel theories.

5. References

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